

# PAGE MONITORING METHOD AND APPARATUS

## BACKGROUND

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### I. Technical Field

The present invention relates to wireless communications. More particularly, the present invention relates to a novel and improved method and apparatus for monitoring page messages in spread spectrum communications.

### II. Background

*filed 9/30/94, now Abandoned*

In U.S. Patent Application Serial No. 08/316,177, entitled "Multipath Search Processor For A Spread Spectrum Multiple Access Communication System" (the '177 application), incorporated by reference herein and assigned to the assignee of the present invention, a searcher for detecting spread spectrum signals is described. The searcher is particularly suited for use in a CDMA based digital cellular telephone system to identify pilot channels transmitted within the CDMA system. Once the pilot channel is identified, the telephone, or "subscriber unit," uses the associated timing information to perform functions such as monitoring for page messages and conducting communications.

The searcher according to the '177 application typically works in combination with a set of finger elements and a decoder placed on a single integrated circuit. Together, the components perform the processing necessary for CDMA communications and page monitoring. For example, to receive a CDMA signal the searcher does pilot channel searching at various offsets in time. Once a pilot channel is detected, the finger elements are activated to process an associated data channel, such as a paging channel or a traffic channel. To perform the searching and the signal processing, the searcher and finger elements receive samples generated in response to RF signals received by the subscriber unit. The samples are typically generated by an RF/IF unit within the mobile phone or subscriber unit.

In general, it is desirable to reduce the power consumption of a subscriber unit to reduce the battery size and weight. Additionally, it is desirable to increase the reliability with which pages and other messages are received and processed by the subscriber unit.

## SUMMARY OF THE INVENTION

The presently disclosed method and apparatus are directed to a novel and improved technique monitoring and receiving on one or more paging channels. In one aspect of the invention, a searcher is used to detect spread spectrum signals. The searcher advantageously searches several pilot channels associated with several base stations. A controller selects at least two base stations that have associated pilot signal energies exceeding a threshold. A demodulator demodulates paging channels transmitted by the at least two base stations. The paging channels are advantageously transmitted over substantially overlapping time slots. A combiner combines a result of the demodulation generated by demodulating each of the paging channels.

## BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

**FIG. 1** depicts a cellular telephone system configured in accordance with an embodiment of the invention;

**FIG. 2** depicts a block diagram of a receiver portion of a subscriber unit configured in accordance with an embodiment of the invention;

**FIG. 3** depicts a flow chart illustrating the processing steps performed within a subscriber unit when performed in accordance with an embodiment of the invention;

**FIG. 4** depicts a block diagram of a searcher when configured in accordance with an embodiment of the invention; and

**FIG. 5** depicts an example of a pilot signal  $E_c/I_o$  fluctuation between transmissions of quick paging channels and paging channels.

## DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

A novel and improved method and apparatus for detecting paging messages are described. The exemplary embodiment described herein is set forth in the context of a digital cellular telephone system. While use within this

context is advantageous, different embodiments of the invention may be incorporated in different environments or configurations. In general, the various systems described herein may be formed using software-controlled processors, integrated circuits, or discrete logic. Implementation in an integrated circuit is advantageous. The data, instructions, commands, information, signals, symbols, and chips that may be referenced throughout the application are advantageously represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or a combination thereof. In addition, the blocks shown in each block diagram may represent hardware or method steps.

**Fig. 1** is a block diagram of a cellular telephone system configured in accordance with one embodiment. Mobile telephones and other communication systems (subscriber units) **10** are located among base stations **12**, which are coupled to a base station controller (BSC) **14**. Mobile switching center (MSC) **16** connects BSC **14** to the public switch telephone network (PSTN)/public data system network (PDSN) **18**. BSC **14** may be connected to other base station controllers (not shown for simplicity). Similarly, MSC **16** may be connected to other base station controllers and mobile station controllers (not shown for simplicity). During operation, some mobile telephones **10** conduct telephone calls by interfacing with base stations **12** while others are in an idle, or standby, mode in which they monitor for page messages.

In accordance with the use of some CDMA communications protocols, a subscriber unit **10** can simultaneously interface with two base stations **12** in soft handoff. A system and method for operating a cellular telephone using CDMA techniques is described in U.S. Patent No. 5,103,459 entitled "System and Method for Generating Signal Waveforms in a CDMA Cellular Telephone System", (the '459 patent), assigned to the assignee of the present invention and incorporated by reference herein. The system of the '459 patent is configured substantially in accordance with the use of the IS-95 over-the-air interface standard.

Additionally, in one embodiment of the invention, paging of a subscriber unit **10** is performed substantially in accordance with the paging method described in U.S. Patent Applications Serial Nos. <sup>6,111,845</sup> ~~08/865,650~~ and <sup>6,393,245</sup> ~~08/890,355~~, both entitled "Dual Channel Slotted Paging," (the dual channel paging applications), assigned to the assignee of the present invention and incorporated by reference herein, and wherein the use of a quick paging message (quick page) transmitted over a reduced encoding channel is

described. One or more quick pages are transmitted before the full page message (full page) to allow a subscriber unit to reduce page monitoring time, and therefore reduce standby power consumption. Generally, if the subscriber unit does not receive a positive quick page, then it does not monitor for the full page, thereby reducing idle mode power consumption.

Fig. 2 is a block diagram of a demodulator used for processing CDMA signals in accordance with one embodiment of the invention. Receive (Rx) samples are generated by radio frequency/intermediate frequency (RF/IF) system 190 and antenna system 192, which receive RF signals, filter, downconvert, and digitize the RF signals to baseband. The samples are supplied to mux 202 and sample RAM 204. The output of mux 202 is supplied to searcher unit 206 and finger elements 208, which are coupled to control unit 210. Combiner 212 couples decoder 214 to finger elements 208. Typically, control unit 210 is a microprocessor controlled by software, and may be located on the same integrated circuit or on a separate integrated circuit.

During operation, receive samples (samples) are stored in sample RAM 204 and applied to mux 202. Mux 202 supplies either real time samples or the stored sample to searcher unit 206 and finger elements 208. Control unit 210 configures finger elements 208 to perform demodulation at different time offsets based on search results from searcher unit 206. The results of the demodulation are combined in combiner 212 and passed to decoder 214, which outputs the data.

In general, the searching performed by searcher 206 uses non-coherent demodulation of the pilot channel to test timing hypotheses corresponding to various sectors, base stations and multi-paths, while the demodulation performed by finger elements 208 is performed via coherent demodulation of the data channel. Non-coherent demodulation does not require carrier phase information, but detects signal energy rather than the data contained in the signal (for certain waveform types). Throughout this application, the term demodulation alone refers to coherent demodulation, while searching refers to non-coherent demodulation. In one embodiment of the invention, despreading is performed by multiplying the received samples with the complex conjugate of the PN sequence and assigned Walsh function at a single timing hypothesis and digitally filtering the resulting samples, often with an integrate and dump accumulator circuit.

The demodulation and searching can be performed at various time offsets, and the results of the demodulation are combined to determine if a page

message was received. Advantageously, the page channel demodulated by searcher is similar to the quick paging channel described in the dual channel paging applications referenced above. As the message duration is small for quick paging (128 or 256 PN chips at 1.2288 Mega chip per second (Mcps) is 104 or 208 microseconds) and the necessary de-skew is small, (about 100-400 microseconds) the required received samples can be readily buffered and processed "off-line" to save power.

Fig. 3 is a flow chart illustrating the operation of the demodulator of Fig. 2 during idle mode in accordance with an embodiment of the invention. Idle mode is the state in which the subscriber unit is powered up but not making a call. During idle mode the subscriber unit monitors for paging messages directed to it. The paging message may indicate an incoming communication or telephone call.

At step 300, the subscriber unit collects and stores received samples during the quick paging slot assigned to it. In one embodiment, the collection is performed by activating the RF/IF system 190, storing the samples in the sample RAM, and then deactivating the RF/IF system 190. Typically the subscriber unit collects samples for a longer duration than that of a single quick paging slot so that multiple time offset signals are stored within the set of received samples. In another embodiment, the samples pass to searcher unit 206 in real time without being stored.

At step 304 searcher unit 206 (of Fig. 2) performs pilot searching on the samples at various time offsets. Additionally, pilot searching may be performed for different signals. For example, searching may be performed for signals from different base stations that use different, or differently offset, pilot codes. When a local maxima is detected above a certain threshold, and the combine function is enabled for the particular search window, the resulting hypothesis is demodulated and combined. Once all the hypotheses in a search list have been completed, the step is done.

In one embodiment of the invention, it is advantageous to have samples large enough to cover the time offset of a set of multipath signals. Thus, by simply searching the same set of samples at different offsets, different pilots may be detected. Similarly, the same set of samples may be demodulated at different offsets to process quick pages. While a quick page channel designed for coherent signaling provides better performance, and therefore is advantageous in many instances, a quick paging system may be designed for non-coherent signaling as well.

At step 306, searcher 206 is switched to demodulation mode, and the paging channel associated with each signal detected during search mode is demodulated to determine if a quick page has been received. The quick pages are processed by performing coherent demodulation on the set of paging channels corresponding to the set of pilot channels detected during searching. Thus, in one embodiment of the invention, the quick page channel is demodulated within the searcher after the searching is performed. Each demodulation is performed at a particular offset within the samples, and the resulting set of demodulation soft decision data is diversity combined using an accumulator within searcher 206.

At step 308 the combined demodulation data is examined to determine if a positive quick page has been received (i.e., one indicating that the following full paging message may be directed to the particular subscriber unit). If a positive quick page has not been received, the subscriber unit returns to step 300. If a positive quick page has been received, the finger elements 208, decoder 214 and RF/IF unit 190 are activated at step 310, and the full page processed at step 312. In an alternative embodiment of the invention, the subscriber unit continues to search the samples for other pilots to find new signals to process when the next paging slot occurs. Additionally, if the quick paging channel was not received with sufficient quality, then step 310 is performed anyway to ensure that a full-page message is not missed.

By performing both the searching and quick page processing within searcher unit 206, the quick paging channel can be monitored without having to activate finger elements until a positive quick page is received. Generally, most quick page messages will be negative, indicating that no call or message is pending. Thus, the time the finger elements 208 and other circuitry are activated is significantly reduced. Therefore, reducing the circuitry used to perform quick page channel monitoring increases the standby time of the subscriber unit.

This reduction in circuitry is accomplished by taking advantage of the reduced coding level of the quick paging channel and quick page message and storing received samples for processing. The reduced coding allows the demodulation of the quick paging channel to be performed with a limited amount of demodulation functionality, and therefore with limited additional complexity in the searcher. Also, the use of sample RAM 204 allows multiple time offset demodulation to be performed using a single demodulation engine

within searcher 206, which further reduces the circuitry necessary to monitor for paging messages.

Additional power savings are realized by performing the search and page channel monitoring using stored samples. In one embodiment, the quick  
5    paging channel is an uncoded binary phase shift keying (BPSK) or on-off-keying (OOK) bit sent once or twice. In particular, the time that the RF/IF unit 190 operates during each page cycle is reduced by storing the samples when they are generated. Once the samples are stored, the subscriber unit deactivates the RF/IF unit 190 to conserve power, and searches the samples repeatedly at  
10    different offsets or different pilot signals, or both, using only the digital circuitry.

As noted above, performing different searches on the same samples allows the RF unit to turn off once the initial set of samples is gathered. Turning off the RF unit reduces the power consumption of the mobile during  
15    idle mode. In contrast, if the samples were not stored, additional samples would have to be gathered for as long as it was necessary to search for the various pilot signals and time offsets. This continuous gathering of pilot data would require the RF unit to remain on, and therefore consuming power, for a longer period of time, which would reduce the stand-by time of the subscriber  
20    unit.

The described embodiments of the invention provide performance enhancements as well as improved idle mode power consumption. In particular, by performing demodulation and searching on the same set of samples, the performance of the demodulation is improved. This is because  
25    the best signals as measured by the pilot channel searching will be the best signals for paging channel demodulation because the set of samples are the same. In alternative systems, searching is performed on a first set of samples and the results of that searching are used to determine how to demodulate paging channels in a second set of samples. While the correspondence between  
30    the searching results and paging channel quality is typically reasonable if the time span between the two events is small, any difference in the channel between the search and demodulation is virtually eliminated when compared to fading channel decorrelation time by conducting searching and demodulation on the same samples.

35    Fig. 4 is a block diagram of searcher 206 when configured in accordance with one embodiment of the invention. The in-phase and quadrature phase samples are read from sample RAM 204 (Fig. 2) and despread by quadrature

phase shift keying (QPSK) desreader 402 using a pseudo random noise (PN) code from PN code generator 404, where the PN code comprises an in-phase portion (PNI) and a quadrature phase portion (PNQ). The resulting in-phase and quadrature phase components from QPSK desreader 402 are applied to multipliers 406a - 406d. Processing after the sample RAM 204 may happen at arbitrary clock frequencies, such as 19 MHz, that are unrelated to the original chip rate.

During search mode, Walsh code generators 408 and 410 generate the pilot channel Walsh code, which is applied to multipliers 406a - 406d. Multipliers 406a - 406d and accumulators 408a - 408d operate together to discover the de-spread samples with the pilot Walsh code from Pilot Walsh code generators 408 and 410.

The discovered pilot samples from accumulators 408a and 408b are applied to multipliers 420 twice: once directly and once via multiplexers 423. By applying the discovered pilot samples twice, the result is that the discovered pilot samples are squared. The squared outputs are summed by a summer 422. Thus, in search mode, the dot product of the discovered pilot data is calculated, and therefore the correlation energy of the pilot channel at the current offset is calculated.

Similarly, the discovered pilot samples from accumulators 408c and 408d are applied to square circuits 410. The outputs of square circuits 410 are summed by a summer 412. Thus, the operations by square circuits 410 and summer 412 act to calculate the dot product of the discovered pilot data with itself, and therefore the correlation energy of the pilot channel at the current offset.

The dot products from summers 412 and 422 are received by a local maxima calculator 414. Local maxima calculator 414 determines the most likely offset, or offsets, from a set of offsets (or hypothesis) attempted by the searcher based on the correlation energy. For example, local max calculator 414 may save the local largest energy in a set of oversampled correlation energies in order to isolate the sample nearest to the true offset. Multipliers 406a and 406b and accumulators 408a and 408b operate together to discover the despread samples with the quick paging Walsh code from quick page Walsh code generator.

The set of offsets is generated as the timing of the PN and Walsh codes are adjusted relative to the samples. In an exemplary search, the PN and Walsh codes are adjusted in small increments around particular search regions.



Typically, the code generators are configured by a control system which also defines the search regions with a start offset and a finish offset. The control system may be a microprocessor or digital signal processor controlled by software stored in memory.

5        N-max tracker 416 collects the set of N largest correlation energies for the different search regions. N is an integer, advantageously in the range of 4 to 16. The use of other criteria for collecting search results, such as diversity of signal source, is consistent with the use of the invention. The resulting set of correlation energies and associated offsets (search results) is reported to the  
10    control system.

      In the exemplary embodiment of the invention, once the search operation has been performed, the control system configures the searcher to perform demodulation on the paging channel for a set of signals and offsets based on the search results. To perform demodulation of the page channel (advantageously  
15    the quick page channel), Walsh generator 410 is configured to generate the paging channel Walsh code, and multiplexers 423 are configured to apply the output of accumulators 408c and 408d to multipliers 420. Additionally, accumulators 408a and 408b are configured to integrate exactly over the bit duration.

20        For each signal to be demodulated, the control system configures the PN generator and Walsh generators at the particular offset, and the samples are demodulated again. The quick paging channel discovered samples from accumulators 408a and 408b are applied to multipliers 420. Additionally, the pilot channel discovered samples are applied to multipliers 420 via muxes 423.

25        To perform the dot product of pilot and paging data, the outputs of multipliers 420 are added by adder 422, and the resulting projected quick paging channel soft decision data is received by latches 424. Various other methods for adjusting for carrier phase will be apparent including the use of a cross product operation or other phase rotation methods. The dot product  
30    recovers the data that is in-phase with the pilots. Additionally, this data is weighted for combining. The output of latches 424 is then received by combiner accumulator 426. For each signal demodulated, accumulator 426 adds in the demodulation results. Once the set of signals is demodulated, the combined quick page data is output to the control system, which estimates the  
35    data transmitted by making a hard decision based on the accumulated soft decision data. Based on the hard decision, it is determined whether a quick page has been sent.

Additionally, in one embodiment of the invention, the energy from the discovered pilot channel data is calculated again by performing a dot product operation, and the resulting pilot energy is accumulated for each signal by accumulator 426. The accumulated pilot energy is forwarded to the control system.

In one embodiment of the invention, the control system determines whether to rely on the quick paging data based on the accumulated pilot energy. If the accumulated pilot energy is above a certain threshold, then the quick paging channel results are relied on. Otherwise, the next quick page slot is processed, or the full paging channel is processed. As noted above, using the same samples being used for the processing of the pilot and paging channels ensures that the channel is the same for the two processings, which improves demodulation performance.

The mobile station may receive pilot signals from several base stations at the same time. One of the base stations with the strongest  $E_c/I_o$  may be monitored by the mobile station. When a quick page message on a quick paging channel (QPCH) is targeted for a mobile station, the quick page may be transmitted via several base stations. Multiple transmissions of the quick page are performed to assure that the mobile station receives at least one of the messages. The mobile station may be monitoring the base station with the strongest pilot  $E_c/I_o$ , and if the quick page message is at least transmitted via the strongest base station, the mobile station detects the quick page message. The actual page message is followed at some time later than the transmission time of the quick page. The mobile station may be moving in the coverage area or the channel condition changing at a rate such that when the actual page message is arrived, the originally identified best base station is no longer the best base station. As a result, the mobile station may fail to detect the actual page message.

In order to improve efficiency of detecting a page message, according to an embodiment of the invention, the mobile station keeps track of several base stations as the best base stations. Referring to Fig. 5, pilot signal  $E_c/I_o$  over time as received by a mobile station is shown. The signals 501-03 are respectively from three different base stations. More base stations could be used. However, for simplicity only three are shown. Each base station transmits a QPCH message 521 to be received by a target mobile station. Note that, at the time of QPCH message 521, the pilot  $E_c/I_o$  of signal 501 is higher than other pilot  $E_c/I_o$  levels. Thus, the base station associated with the pilot

signal 501 is considered the best base station. The QPCH message 521 basically contains information that a paging message 522 is going to follow for the mobile station. The paging message 522 is followed at a determined time following the QPCH message timing.

5 In a synchronized system, QPCH message 521 may be transmitted by different base stations at substantially the same time. Considering the propagation delay and other factors, QPCH message 521 may also be received at the mobile station substantially at the same time. As a result, the paging message 522 following QCPH message 521 is also transmitted from different  
10 base stations at substantially the same time, and received at substantially the same time. Note that, at the time of paging message 522, the base station associated with the pilot signal 501 may not be the best base station. If the mobile station limits the paging message detection to only the best base station as detected during the QPCH 521, the mobile station may fail to properly  
15 decode the paging message.

In order to solve the problem associated with the changes in the channel between the transmission time of the QPCH message 521 and the paging message 522, the mobile station tracks more than one base station as the best base station. The mobile station decides whether the  $E_c/I_o$  of the pilot signal of  
20 different base stations during the QPCH message exceeds a threshold 510. Such a decision may be performed by control system 210 in connection with the operations performed by searcher 206 and finger elements 208 as described. If the  $E_c/I_o$  exceeds threshold 510, the mobile station monitors the paging message 522 transmitted from all the base stations that exceeded the threshold.

25 Monitoring multiple paging messages at the same time may be accomplished by several ways. One way is to assign at least a finger to signals arriving from each base station. If there is more than one signal path from a base station, more than one finger may be assigned to each base station. The results of the assigned fingers to a base station are summed in the form of the  
30 data symbol energy. In order to sum the signal energies from different base stations, the results may need to be time aligned by time skewing the signal energies. The summed signal energies are applied to a decoder for decoding the paging message 522. The combined and de-skewed results of fingers assigned to a base station may pass through a de-interleaving process if the  
35 signal at the transmitting base station has been passed through an interleaving process. Interleaving and de-interleaving processes are known in the relevant art. The results of de-interleaving processes associated with signals from each

base station pass through a decoding process for decoding the paging message 522. In a limited way, the signals from different base stations may be sampled and stored for a serial combining and decoding process.

In an alternative embodiment, the mobile station may keep track of several base stations as the best base stations for detecting paging message 522 independent of the QPCH messaging. The best base stations in the alternative embodiment may be pre-selected. The pre-selection may be based on criteria other than QPCH message reception or the pilot signal being above the threshold 510. For example, the mobile station may remain in approximately the same geographical areas in a low mobility situation. Therefore, the number of base stations surrounding the mobile station may remain constant. In this situation, the mobile station may wake up periodically based on an internal timing control to monitor the paging channel. If there is a paging message, the mobile station monitors the signals from all the pre-identified base stations.

The mobile station may wake up slightly ahead of time to search for pilot channels associated with the base stations that possibly carry a paging a message for the mobile station. The wake up time may be long after the QPCH timing but before the paging channel timing.

The mobile station may attempt to receive and decode paging channels transmitted from several base stations even though only one QPCH may have been detected during the QPCH timing. In such a situation, the mobile station, after detecting a QPCH from a base station, knows that most likely several base stations in the vicinity may send the page message. As such, the mobile station may limit its search during the QPCH channel to detection of only one QPCH. However, the mobile station advantageously continues to monitor several base stations for the actual page message. To select candidate base stations for detection of the paging message after detection of only one QPCH, the mobile station may wake up just before the paging channel timing as determined based on the detected QPCH timing for detecting pilot channels of the candidate base stations.

Thus, a system and method for performing page monitoring have been described. The previous description of specific embodiments is provided to enable any person skilled in the art to make or use the present invention. The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty. Thus, the present invention is not intended to be limited to the embodiments shown herein but is

to be accorded the widest scope consistent with the principles and novel features disclosed herein.

**What is claimed is:**

11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041 1042 1043 1044